



Biological Treatment for Removal of the Odorants Geosmin and MIB in Surface Water Prior to Conventional Treatment

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INTRODUCTION

Lake Manatee, the source for the Manatee County Water Treatment Plant (WTP), is subject to seasonal cyanobacteria blooms which release the odorants 2-methylisoborneol (MIB) and geosmin into the raw water. These compounds impart an earthy/musty taste and odor to the water. Conventional treatment at the WTP does not remove the odorants, which can be detected by consumers at concentrations as low as 5-10 ng/L. The WTP currently uses powdered activated carbon (PAC) when necessary to remove the odorants. PAC is expensive and not always effective due to high concentrations of odorants, chemical feed limitations and a short contact time (~3 min) with the raw water. A pilot study was initiated in January 2009 to evaluate direct biological filtration of surface water prior to conventional treatment for removal of MIB and geosmin. Biological treatment prior to conventional treatment would utilize the background nutrients of the water source, avoid the potential risks associated with a biological process at the end of the treatment process, while still allowing for the addition of PAC prior to biofiltration if ever needed.

PAC and Odorant History, 2001-2010

Year	PAC		Raw Max (ng/L)		# Days Finished > Target
	Lbs	Cost	MIB	Geosmin	
2001	995K	\$385K	35	212	3
2002	634K	\$245K	165	58	8
2003	200K	\$78K	10	20	0
2004	553K	\$214K	56	52	11
2005	35K	\$9K	5	20	1
2006	1.5M	\$408K	40	2432	23
2007	1.5M	\$721K	51	904	27
2008	1.7M	\$1.1M	76	352	46
2009	346K	\$228K	63	72	14
2010	369K	\$292K	36	147	6
2015	984K	\$605K	85	318	48

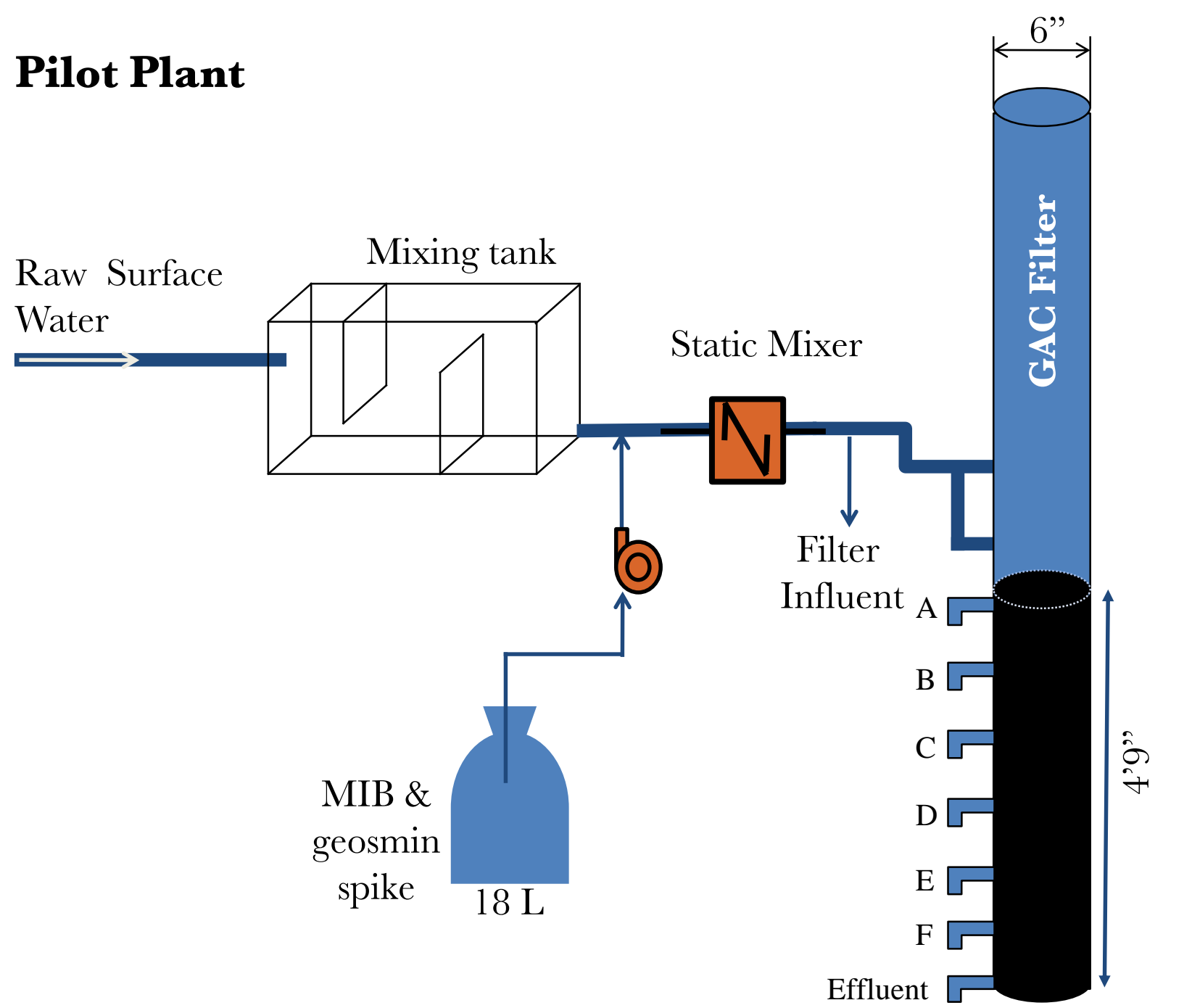
Lake Manatee Odorant Levels, 2001-2010 (ng/L)

Odorant	Maximum	99 th Percentile	95 th Percentile	# Days > 99 th	Treatment Target
MIB	165	74	35	14	12
Geosmin	2432	564	129	9	7



EXPERIMENTAL DESIGN

The pilot scale biofilter consisted of a 6” column filled with granular activated carbon (GAC) to a bed depth of 4’9”. The GAC adsorption capacity was exhausted and the filter allowed to colonize with bacteria naturally present in the raw water from Lake Manatee. Ports added along the length of the column allowed for sampling of the water at multiple empty bed contact times (EBCTs) in a single spiking experiment. Odorants were spiked into the raw water at various concentrations and allowed to pass through the filter column. Samples were collected at the influent to the filter, from the various sample ports, and of the filter effluent and measured for MIB and geosmin using solid-phase microextraction gas chromatography/mass spectrometry (SPME-GC/MS). In addition to the odorants, TOC, DOC, turbidity, color, UV254, conductivity, pH, DO, temperature, and filter headloss were monitored. Experiments also examined whether supplementing with nitrogen would improve odorant removal (Lake Manatee is N limited), if the biofilters could remove dissolved manganese, and if adding PAC prior to biofiltration is a viable treatment option. A bench-scale experiment was performed to determine the ability of the biofilter to remove microcystin toxin.



OBJECTIVES

- Determine the Empty Bed Contact Times (EBCTs) required to remove MIB and geosmin at historical benchmark levels to below threshold values (7 ng/L geosmin, 12 ng/L MIB) using biological filtration.
- Evaluate the feasibility of biological filtration to remove other constituents of concern to the WTP (dissolved manganese, TOC, microcystin).

“BIOLOGICAL TREATMENT UNIT”

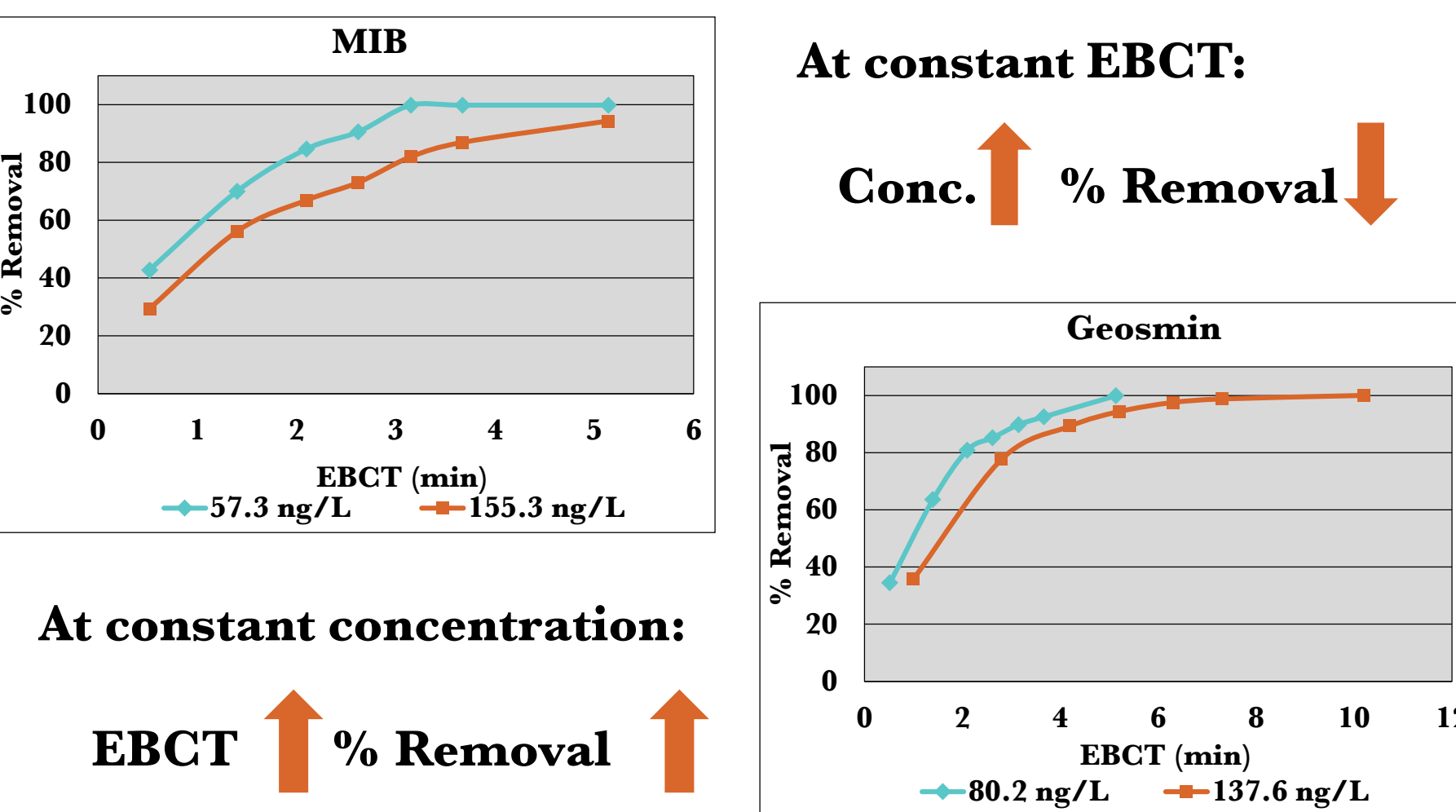
- Full scale system based on biological filtration research
- 6 GAC “filters” for treatment of Lake Manatee surface water prior to conventional treatment basins
- At full treatment capacity (54 MGD):
 - 3.6 minute EBCT, 3.0 min with one filter out of service
 - 92% “reliability” for geosmin, >99% for MIB
- 7.2 min EBCT at “average flow” (37 MGD)
- No chemical additions planned
- Designed by McKim & Creed
- Construction contract awarded to Vogel Bros. for ~\$18M
- Construction to begin summer 2016

SUMMARY OF RESULTS

Odorant Removal

Direct biological filtration of raw surface water prior to conventional treatment was shown to be an effective treatment option for removal of the odorants MIB and geosmin. Removal is dependent on both the EBCT used (direct relationship) and the influent odorant concentration (inverse relationship). To remove geosmin and MIB up to the historical maximum values, EBCTs of 12 and 5 minutes, respectively, are required. Temperature does not affect odorant removal over the observed range (11-32 °C). Supplementation with nitrogen does not increase removal. Addition of PAC prior to biological filtration does not improve removals, but it does not hinder filter performance either and is a viable treatment option.

Selected Data and EBCT/Concentration/Removal Relationships



EBCTs Required to Remove Odorants at Benchmark Levels

Odorant	95 th Percentile		99 th Percentile		Maximum	
	Conc. (ng/L)	EBCT (min.)	Conc. (ng/L)	EBCT (min.)	Conc. (ng/L)	EBCT (min.)
MIB	35	1.5	74	2.5	165	5.0
Geosmin	129	6.5	564	10	2432	12

Other Constituents of Concern

- Removal of TOC, DOC, color, and turbidity is minimal through the biofilter column.
- Dissolved manganese is removed through the biofilter; Mn is a concern at the WTP due to a planned upgrade to ultrafiltration membranes. Preliminary results indicate 50-80% removal through the biofilter.
- Future work will investigate whether the biofilter can remove other trace organic compounds (pesticides, etc.).

Removal of Algal Toxins

Bench-scale testing of a microcystin-LR spike indicated up to 23% removal through the biofilter using a 6.3 min EBCT.

Microcystin-LR Spike Experiment

Date	Influent (ug/L)	Effluent (ug/L)	% Removal
7/14/2015	14.8	13.8	6.8
7/15/2015	23.3	18.0	22.7
7/16/2015	20.7	16.9	18.4

